UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/631,884	07/29/2003	David S. Taubman	10991918-2	1836

7590   05/25/2006

· HEWLETT-PACKARD COMPANY
Intellectual Property Administration
P.O. Box 272400
Fort Collins, CO 80527-2400

OIPE

JUN 05 2006

PATENT & TRADEMARK OFFICE

EXAMINER
CHEN, WENPENG

ART UNIT	PAPER NUMBER
2624	

DATE MAILED: 05/25/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

	Application No.	Applicant(s)
Office Action Summary	10/631,884	TAUBMAN, DAVID S.
	Examiner	Art Unit	
	Wenpeng Chen	2624	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE <u>3</u> MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1) ☒ Responsive to communication(s) filed on <u>*17 March 2006*</u>.

2a) ☐ This action is **FINAL**.   2b) ☒ This action is non-final.

3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4) ☒ Claim(s) *1-10 and 12-18* is/are pending in the application.

    4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5) ☐ Claim(s) _____ is/are allowed.

6) ☒ Claim(s) *1-10, 12-18* is/are rejected.

7) ☐ Claim(s) _____ is/are objected to.

8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9) ☐ The specification is objected to by the Examiner.

10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.

    Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

    Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

    a) ☐ All   b) ☐ Some * c) ☐ None of:

      1. ☐ Certified copies of the priority documents have been received.

      2. ☐ Certified copies of the priority documents have been received in Application No. _____.

      3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

    * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
    Paper No(s)/Mail Date _____.

4) ☐ Interview Summary (PTO-413)
    Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

Examiner's Remarks

1.   Applicant's amendments filed on 3/17/06 overcome the following set forth in paper #20051207 mailed on 12/192005:

-- objection to claims (paragraph 2.)

2.   Applicant's terminal disclaimer filed on 3/17/06 overcome the following set forth in paper #20051207 mailed on 12/192005:

-- rejection to Claims 1-5 and 12-18 on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-8 of U.S. Patent No. 6,658,159);

-- rejection to Claims 6-10 on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-4 of U.S. Patent No. 6,658,159 in view of JPEG2000.

3.   Applicant's declaration under 37 CFR 1.131 filed on 3/17/06 disqualifies (1) "JPEG 2000 IMAGE CODING SYSTEM," JPEG 2000 Final committee draft version 1.0, 16 March 2000" and (2) Budge et al. (US Patent Application Publication 2002/0080408) as prior art. As a consequence, the Examiner withdraws the following set forth in paper #20051207 mailed on 12/192005:

-- rejections to Claims 1-10 and 12-18 under 35 U.S.C. 102(a) as being anticipated by "JPEG 2000 IMAGE CODING SYSTEM," JPEG 2000 Final committee draft version 1.0, 16 March 2000";

-- rejections to Claims 1-10 and 12-18 under 35 U.S.C. 103(a) as being unpatentable over the admitted prior art (pages 2-3, last paragraph in page 7) in view of Schwartz et al. (US patent 5,815,097) and Budge et al. (US Patent Application Publication 2002/0080408.)

4.   A new ground of rejection is provided below. This Action is made non-final due to the declaration under 37 CFR 1.131.

Claim Rejections - 35 USC § 103

5.   The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6.   Claims 1-10 and 12-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over the admitted prior art (pages 2-3, last paragraph in page 7) in view of Christopoulos et al. (WO 99/16250.)

a.   With regard to Claims 1-10, the admitted prior art (pages 2-3) disclosed the JPEG 2000 algorism that teaches method and system for compressing image data, comprising the steps/components for:

-- decomposing the image data into code-blocks of coefficients using a transform, each code-block comprising a plurality of bit-planes from a most significant bit-plane to a least significant bit-plane; (page 3)

-- forming an encoded bit-stream by coding bit-planes of coefficient data in the code-blocks according to an arithmetic coding scheme in order to form an encoded bit-stream; (page 3)

-- wherein the arithmetic coding scheme operates in a plurality of coding passes; (page 3; Each coding of a bit plane is a pass.)

-- wherein the method for compressing image data is based on embedded block coding with optimized truncation and employs a Wavelet transform. (The last paragraph in page 7 of the present specification admitted that EBCOT is a prior art as published in the document N 1020R on 10/21/1998.)

The system cited in JPEG 2000 Image Coding System document (page 2) implicitly teaches all components to implement the above features.

However, the admitted prior art does not teach the feature that "coefficient data from at least one bit-plane is included in the encoded bit-stream without arithmetic coding."

Christopoulos teaches a compression system and method:

-- coefficient data from at least one bit-plane is included in the encoded bit-stream without arithmetic coding. (last paragraph, page 2; paragraph 2, page 3; paragraph 1, page 9; paragraphs 2 and 5, page 11; Fig. 2; The coding is done in a bit-plane basis and applicable to wavelet transformed coefficients. The raw bits are included in the encoded bit-stream without

arithmetic coding because there is little to gain. Fig. 2 shows that there are 4 rawbits in the LSB side.)

It is desirable for reducing unnecessary coding operations to simplify and speed up coding process. It would have been obvious to one of ordinary skill in the art, at the time of the invention, to apply Christopoulos' teachings to bypass arithmetic coding of the K least significant bit-planes of the data taught in the admitted prior art, because the combination provides an advantage of reducing the entropy coding operations. Accordingly, the combination teaches:

-- wherein the arithmetic coding scheme operates in a plurality of coding passes, and wherein at least one of the arithmetic coding passes for the coefficient data from said at least one bit-plane is not performed during the image data compression;

-- wherein coefficient data from bit-planes $p < po-K$ are written directly into the encoded bit-stream without arithmetic coding, wherein po denotes the most significant bit-plane of the code block in which any sample therein becomes contextually significant during arithmetic coding and K is an integer parameter; (In the combination, the N-K bit-planes are arithmetic coded.)

- wherein K includes 3, (It is well known that a pixel usually has 8 bits. Schwartz teaches in column 11, lines 21-27 that three or four entropy coding operations are performed on the amplitude data.)

The combinations as cited above also teach the system Claims 6-10.

b.   With regard to Claim 12, because (1) each code-block taught in the admitted prior

art is coded and transmitted one by one and (2) the combination teaches coding each code-block

with and without arithmetic coding, the combination also teaches the feature that arithmetically

coded bit-plane data is interleaved with the bit plane coefficient data included in the bit-stream

without arithmetic coding.

c.   With regard to Claims 13-18, the admitted prior art (pages 2-3) disclosed the

JPEG 2000 algorism that teaches method and system for compressing image data, comprising the

steps/components for:

-- decomposing the image data into code-blocks of coefficients using a transform, each

code-block comprising a plurality of bit-planes from a most significant bit-plane to a least

significant bit-plane; (page 3)

-- processing bit-planes of coefficient data in the code blocks in multiple coding passes to

generate raw bit-plane data; (page 3; block 22 of Fig. 1; Each coding of a bit plane is a pass.)

-- coding bit-planes of coefficient data in the code-blocks according to an arithmetic

coding scheme in order to form an encoded bit-stream; (page 3)

-- wherein the arithmetic coding scheme operates in a plurality of coding passes; (page 3;

block 22 of Fig. 1.)

-- wherein the method for compressing image data is based on embedded block coding

with optimized truncation and employs a Wavelet transform. (The last paragraph in page 7 of the

present specification admitted that EBCOT is a prior art as published in the document N 1020R

on 10/21/1998.)

The system cited in JPEG 2000 Image Coding System document (page 2) implicitly teaches all components to implement the above features.

However, the admitted prior art does not teach the recited features related to (1) "the step of coding a portion of raw bit-plane data" and "the step of writing coded data and raw data not arithmetic coded into a bit-stream."

Christopoulos teaches a compression system and method:

-- coefficient data from at least one bit-plane is included in the encoded bit-stream without arithmetic coding. (last paragraph, page 2; paragraph 2, page 3; paragraph 1, page 9; paragraphs 2 and 5, page 11; Fig. 2; The coding is done in a bit-plane basis and applicable to wavelet transformed coefficients. The raw bits are included in the encoded bit-stream without arithmetic coding because there is little to gain.)

It is desirable for reducing unnecessary coding operations to simplify and speed up coding process. It would have been obvious to one of ordinary skill in the art, at the time of the invention, to apply Christopoulos' teachings to bypass arithmetic coding of the K least significant bit-planes of the data taught in the admitted prior art, because the combination provides an advantage of reducing the entropy coding operations. Accordingly, the combination teaches:

-- arithmetically coding a portion (the most-significant-bit bit-planes) of raw bit-plane data to generate arithmetically coded data;

-- writing the arithmetically coded data and the raw bit-plane data not arithmetically coded (K least-significant-bit bit-planes) directly into a bit-stream, wherein these two data are interleaved; (Because (1) each code-block taught in the admitted prior art is coded and transmitted one by one and (2) the combination teaches coding each code-block with and without arithmetic coding, the combination also teaches the feature that arithmetically coded bit-plane

data is interleaved with the bit plane coefficient data included in the bit-stream without arithmetic coding.)

-- wherein raw bit-plane data generated during at least one coding pass for a prescribed class (the class of least-significant-bit bit-planes) of bit-planes is written directly into the bit-stream;

-- wherein raw bit plane data generated during at least one coding pass for bit-planes $p<po-K$ is written directly into the encoded bit-stream, wherein po denotes the most significant bit-plane of the code block in which any sample therein becomes contextually significant during arithmetic coding and K is an integer parameter; (In the combination, the N-K bit-planes are arithmetic coded in the amplitude coding pass.)

- wherein K includes 3. (It is well known that a pixel usually has 8 bits. Schwartz teaches in column 11, lines 21-27 that three or four entropy coding operations are performed on the

Conclusion

7.   Any inquiry concerning this communication or earlier communications from the examiner should be directed to Wenpeng Chen whose telephone number is 571-272-7431. The examiner can normally be reached on 8:30 am - 5:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Bhavesh Mehta can be reached on 571-272-7453. The fax phone numbers for the organization where this application or proceeding is assigned are 571-273-8300 for regular

communications and 571-273-8300 for After Final communications. TC 2600's customer service number is 571-272-2600.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 571-272-2600.

Wenpeng Chen
Primary Examiner
Art Unit 2624

May 22, 2006

Notice of References Cited

	Application/Control No.	Applicant(s)/Patent Under Reexamination
Notice of References Cited	10/631,884	TAUBMAN, DAVID S.
	Examiner	Art Unit	Page 1 of 1
	Wenpeng Chen	2624	

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-			
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N	WO 9916250 A1	04-1999	World Intellect	CHRISTOPOULOS et al.	H04N 7/30
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PCT

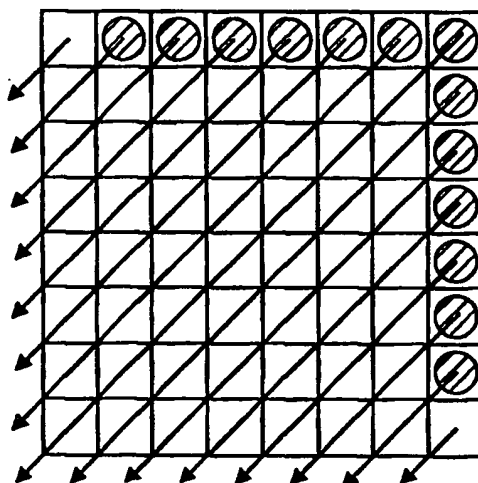## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(54) Title: AN EMBEDDED DCT-BASED STILL IMAGE CODING ALGORITHM

(57) Abstract

In an embedded DCT–based (EDCT) image coding method, decoded images which give better PSNR over earlier JPEG and DCT–based coders are obtained by a scanning order starting, for each bitplane, from the upper left corner of a DCT block (corresponding to the DC coefficient) and transmitting the coefficients in an order of importance. An embedded bit–stream is produced by the encoder. The decoder can cut the bit–stream at any point and therefore reconstruct an image at a lower bitrate. The quality of the reconstructed image at this lower rate is the same as if the image was coded directly at that rate. Near lossless reconstruction of the image is possible, up to the accuracy of the DCT coefficients. The algorithm is very useful in various applications, like WWW, fast browsing of databases, medical imaging, etc.

Diagonal scan of DCT-coefficients

⊘ = Block cut off flag

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AN EMBEDDED DCT-BASED STILL IMAGE CODING ALGORITHM

TECHNICAL FIELD
The present invention relates to a coding algorithm for still images and to a device for executing the algorithm. The algorithm is particularly well suited for generating an embedded bit-stream and for coding parts of the image with different quality than the rest of the image.

BACKGROUND OF THE INVENTION AND PRIOR ART
Transform coding has been widely used in many practical image/video compression systems. The basic idea behind using a transformation is to make the task of compressing the image after transformation easier than direct coding in the spatial domain. The Discrete Cosine Transform (DCT) has been used as the transformation in most of the coding standards as JPEG, H261/H.263 and MPEG.

In recent years most of the research activities have shifted from the DCT to the wavelet transform, especially after Shapiro published his work on embedded zerotree wavelet (EZW) image coding, see J. M. Shapiro, "Embedded Image Coding using zerotrees of wavelet coefficients", IEEE Trans. on Signal Processing, Vol. 41, No. 12, pp. 3445-3462, Dec. 1993.

The paper, W. B. Pennebaker, J. L. Mitchell, JPEG Still Image Data Compression Standard, Van Nostrand Reinhold, New York, 1993 describe the state of the art in DCT-based coding.

In many applications it is desired to obtain an embedded bit-stream. Since an embedded bit-stream contains all lower rates embedded at the beginning of the bit-stream, the bits are ordered from the most important to the less important. Using an embedded code, the encoding simply stops when the target parameter as the bit count is met. In a similar manner, given the embedded bit-stream, the decoder can cease decoding at any point and can produce reconstructions corresponding to all lower-rate encoding.

In order to make the embedded bit-stream optimal it is desired to transmit the bits, which are most significant for the visual perception of an image first. This corresponds to letting the bit-stream have a good compression/quality ratio at low bit rates.

The DCT is orthonormal, which means that it preserves the energy. In other words, with respect to the root mean squared error (RMSE) (or peak signal-to-noise ratio - PSNR) an error in the transformed image of a certain magnitude will produce an error of the same magnitude in the original image.

This means that the coefficients with the largest magnitudes should be transmitted first because they have the largest content of information. This also means that the information can also be ranked according to its binary representation, and the most significant bits should be transmitted first.

After the DCT transformation, most of the energy of the image is concentrated in low frequency coefficients, and the rest of the coefficients have very low values. This

2

means that there are very many zeroes in the most significant bit planes (MSB) of the coefficients. Until the first significant bit (FSB) of a certain coefficient is found, the probability of zero is very high. The task of efficient encoding therefore becomes the task of encoding these zeroes in an efficient way.

In the papers Z. Xiong, O. Guleryuz, M.T. Orchard, A DCT-based embedded image coder, IEEE Signal Processing Letters, Vol. 3, No. 11, pp. 289-290, Nov. 1996, N.K. Laurance, D.M. Monro, Embedded DCT coding with significance masking", Proc.IEEE ICASSP 97 , Vol. IV, pp. 2717-2720, 1997 and J. Li, J. Li, C.-C. Jay Kuo, Layered DCT still image compression, IEEE Trans. On Circuits and Systems for Video Technology, Vol. 7, No. 2, April 1997, pp. 440-442, although DCT is the transform used, the coding of the coefficients is not done in the way that JPEG coding is done. Instead, an embedded bit stream can be produced.

SUMMARY
It is an object of the present invention to provide an algorithm and a device for executing the algorithm, which output an embedded DCT-based (EDCT) image, from which the decoded images give better PSNR over those from JPEG and the DCT-based coders published in the above cited papers.

It is also an object of the invention to provide methods that can be used for encoding Regions of Interest (ROIs) of the image with different quality than the rest of the image, while still keeping the embedded property of the algorithm.

These objects are obtained by a method employing the following basic steps:

- Partition the image into rectangular blocks.

- Transform each block separately with the DCT. The transformation produces a block of coefficients with the DC coefficient in the upper left corner and higher horizontal and vertical frequency coefficients in the direction of the corresponding block axis. Traditionally the blocks used are 8x8 in size, but here any power of two block size is allowed. The reason to restrict the size to a power of two is that then the DCT can be computed fast.

- Quantize and transmit the DCT coefficients in a progressive manner, so that the most important information is transmitted first.

However, in order to make the compression good at every transmission rate, i.e. so that the bit-stream can be cut at any time and still provide an image having a good quality at that compression ratio, an effective scan order needs to be used.

Thus, according to the invention, for each coefficient, the first non-zero bit, starting from the most significant to less significant bits, is called the First significant bit (FSB). The bits of a coefficient prior to the first significant bit will be referred to as the Zero bits (ZBs). The sign information is represented by the Sign bit (SB), while the rest of the bits after the first significant bit are called Raw bits (RBs). Coding is done bitplane by bitplane. In each bitplane, the coding is from the lowest frequency coefficient to the highest frequency.

For every zero bit sent, the length of the uncertainty interval for that coefficient seen by the decoder is divided by two. When the first significant bit is encountered, the sign of the coefficient needs to be sent to maintain an embedded code, as will be described below.

After the sign bit, the RBs have to be transmitted. These contain very little redundancy and there is very little to be gained by trying to encode these with a good prediction.

The receiver can now reverse these steps. The produced bit-stream is embedded and the decoder can therefore cut the bit-stream at any point and generate an image having the same quality as if it was compressed directly at that bitrate.

By using this scan order for such a coding scheme a very good visual quality is obtained for all compression ratios.

BRIEF DESCRIPTION OF THE DRAWINGS
The present invention will now be described in more detail and with reference to the accompanying drawings, in which:

- Fig. 1 illustrates how the DCT coefficients are arranged
- Fig. 2 illustrates the bit order in a pixel
- Fig. 3 illustrates the scan order for an embedded coding
algorithm
- Fig. 4 illustrates the sending of a sign bit
- Fig. 5 illustrates the context for AC coefficient zero bits
- Fig. 6 illustrates the context for DC coefficient zero bits
- Fig. 7 illustrates the context for cut_off signals
- Fig. 8 is a flow chart illustrating the coding procedure

DESCRIPTION OF PREFERRED EMBODIMENTS
In Fig. 1 the arrangement of the DCT coefficients in an 8x8 DCT block is illustrated. Thus, in the upper left corner the low frequency coefficients are found and the higher frequency coefficients are found down and to the right.

Each coefficient is represented by a number of bits, for example 8 as is illustrated in Fig. 2. In Fig. 2 the first three bits are zero, called zero bits (ZB) the fourth bit is not zero and is called first significant bit (FSB) and the bits having lower significance are called raw bits (RB).

In a preferred embodiment the coding algorithm for a digitized DCT transformed image is as follows:

(1) Find the mean value (DC_mean) of all DC coefficients. Subtract this value from each DC coefficient.

(2) Choose a quantizer that is half the size of the largest magnitude coefficient in the image. Transmit this quantizer.

(3) Send/encode the information of which new coefficients are significant with respect to the current quantizer and also the sign of these coefficients. A coefficient is said to

be significant with respect to a quantizer if its magnitude is larger than the current quantizer (in absolute terms) is.

(4) Subtract the current quantizer from the magnitude of the coefficients found to be significant in this bit plane. Replace the significant coefficients magnitude by its magnitude subtracted by the current quantizer. The difference corresponds to keeping only the raw bits.

(5) For all coefficients that have been significant in previous bit planes, send/encode the information of whether the coefficients have a larger or smaller magnitude than the quantizer. Subtract the quantizer from the magnitude of the ones that do and replace those coefficients by the resulted value. This corresponds to transmitting a raw bit.

(6) Divide the current quantizer by two. This corresponds to going down to a less significant bit plane of the coefficients.

(7) Repeat from step (3) until the bit budget is exhausted or some desired quality is reached.

Notice that step 1 above is optional. If it is used, the mean value of the DC coefficients has to be stored/transmitted.

The reconstruction is done as follows:

- Set all coefficients to zero.

- Receive the first quantizer.

- Receive the information about the new significant coefficients.

- Reconstruct these as (1.5 * current quantizer * the coefficient sign). This is because at this stage it is known that the coefficient's magnitude is between current quantizer and (2 * current quantizer). This puts (1.5 * current quantizer) in the middle of the uncertainty interval. The addition or subtraction performed at step 5 below will update the coefficients so that they are always in the middle of the uncertainty interval.

- For all previously significant coefficients, check if the coefficients have a larger magnitude than the current quantizer. Add the current quantizer/2 to the magnitude of the ones that do and subtract the current quantizer/2 from the magnitude from the ones that do not.

- Divide the current quantizer by two.

- Repeat from step 3, i.e. reception of new significant coefficients, until the desired quality is reached or no more information exists.

If step (1) had been performed at the encoder, then the decoder has also received the mean value of the DC coefficients and this value is added to the reconstructed DC coefficients.

5

Furthermore, for updating the coefficients in every bit plane a scan order needs to be defined. In a preferred embodiment one coefficient is updated in all blocks before proceeding to the next coefficient.

Inside a block, the DCT coefficients are scanned in a diagonal order, bit plane by bit plane. After each scanned diagonal, a flag is sent telling if there are any new significant coefficients in the rest of the block. This will be referred to as the block cut_off. The block cut_off is used because in the first bit planes there are so many zeroes that in practice an explicit symbol performs better than trying to code all the zeroes with a good prediction. The block cut off symbols only concern the new significant coefficients.

Notice that instead of having a cut_off flag for each diagonal, run length coding methods could be used. For example, if a coefficient is significant, a number could be used to denote the position of the next significant coefficient in the block.

As explained above a sign bit has already been sent for the previously significant coefficients. The uncertainty interval is therefore double as big for the coefficients not yet significant and these should be considered first in the new scan. Therefore, during each bitplane, first the significance identification is encoded and then the refinement quantization (steps 3 and 5 of the encoding process).

In fig. 4 the reason for sending a sign bit after encountering the first significant bit is illustrated. Thus, after having sent the sign bit the sign of the coefficient is determined and the resulting coefficient is no longer ambiguous.

During each bit plane, the scanning of the coefficients is preferably done in the following manner: first all DC coefficients, then all AC coefficients with the same index, in a diagonal order starting from the upper left corner and ending in the lower right corner of a DCT block of the image, i.e. DC, AC1, AC2, etc...

The zig-zag scanning used in JPEG could also be used without affecting the property of embedded coding of the algorithm.

An embedded bit-stream is in this manner produced by the encoder. The decoder can cut the bit-stream at any point and therefore reconstruct an image at a lower bitrate. The quality of the reconstructed image at this lower rate would be the same as if the image was coder directly at that rate. Near lossless and lossless reconstruction of the image is possible.

The scan order used is illustrated in fig 8. Thus, first in a block 801 the procedure starts. Next in a block 803 a DCT transformation is executed. Thereupon the first bit-plane of the DCT coefficients is extracted in a block 805. The contexts are then reset in a block 807.

Next, the first diagonal is extracted in a block 809 and the first coefficient is extracted in a block 811. The first block is then extracted in a block 813. Then in a block 815 it is checked if the block is already cut. If this is the case the procedure proceeds to a block 817 and else to a block 819.

6

In the block 819 it is checked if the block should be cut off at this movement. If this is the case the procedure proceeds to a block 821 in which a block cut off symbol is transmitted, else the procedure proceeds to a block 823.

In the block 823 it is checked if the coefficient is previously significant, i.e. it is checked if this is the first significant bit (FSB). If the coefficient is previously significant the procedure proceeds to the block 817 and else to a block 825.

In the block 825 it is checked if the coefficient is significant now. If this is the case the procedure proceeds to a block 827 and else to a block 829.

In the block 829 data is sent containing information that the coefficient is not significant and from the block 829 the procedure proceeds to the block 817.

In the block 827 data is sent containing information that the coefficient is significant and from the block 829 the procedure proceeds to the block 817 via a block 831 in which the sign is sent.
In the block 817 it is checked if this is the last block of the DCT image. If this is the case the procedure proceeds to a block 833 and else the procedure returns to the block 815 and repeats the process for the next block.

In the block 833 it is checked is the current coefficient is the last coefficient in the diagonal. If this is the case the procedure proceeds to a block 835 and else it returns to the block 813 for the next coefficient.

In the block 835 it is checked is this diagonal is the last diagonal. If this is the case the procedure proceeds to a block 837 and else it returns to the block 811 for the next diagonal.

In the block 837 the refinement starts. Thus, in the block 837 the first diagonal is extracted. Then in a block 839 the first coefficient in the first diagonal is extracted. Next in a block 841 the first block is contemplated. Thereupon in a block 843 it is checked if the current coefficient is previously significant. If this is not the case the procedure proceeds to a block 847 and else the procedure proceeds to the block 847 via a block 845, in which the raw bits are sent.

In the block 847 it is checked if the current block is the last block. If this is the case the procedure proceeds to a block 849 and else the procedure returns to the block 843 for the next block.

In the block 849 it is checked if the current coefficient is the last in the current diagonal. If this is the case the procedure proceeds to a block 851 and else the procedure returns to the block 841 for the next coefficient.

In the block 851 it is checked if the current diagonal is the last diagonal. If this is the case the procedure proceeds to a block 853 and else the procedure returns to the block 839 for the next diagonal.

In the block 853 it is checked if the current bit plane is the last bit plane. If this is the case the procedure proceeds to a block 855, in which the procedure is terminated, and else the procedure returns to the block 807 for the next bit plane.

To further clarify the scan order and the algorithm in general, pseudo code for the encoder is presented below:

```
Code_image {
  Do forward DCT;

  for(all bitplanes)
    {
      reset_contexts;
      /*significance identification pass*/
      for(all_diagonals)
    {
      for(all_coefficients_in_diagonal)
        {
          for(all_blocks_not_cut_off_already)
            {
              if(cut_off_position) send cut_off_symbol;
              if(coefficient_not_previously_significant)
                {
                  if (significant)
                    {
                      send(significant);
                      send(sign);
                    }
                  else send(not significant);
                }
            }
        }
    }

      /*refinement pass*/
      for(all_diagonals)
    {
      for(all_coefficients_in_diagonal)
        {
          for(all_blocks)
            {
              if(coefficient__significant_in_any_previous_bitplane)
                send(raw_bit);
            }
        }
    }
    }
}
```

8

After the correct scan order has been chosen, it remains to code the scan in an efficient way. The issue is mainly how to encode the mask of the new significant coefficients. Many methods can be used. e.g. Zero tree coding, run length encoding and address switching.

In a preferred embodiment a context-based arithmetic coding is used. An arithmetic coder implemented according to the guidelines provided by Witten et al and described in, I. H. Witten, R. M. Neal, and J. G. Cleary, "Arithmetic coding for data compression", Communications of the ACM, Vol. 30, No. 6, pp. 520-540, June 1987 can then be used.

The adaptive probability estimation can be expanded and customized for bit plane coding as described below.

When using this method, all that needs to be estimated for each symbol, is the probability of that symbol being zero, since the symbol alphabet used is binary. To do this a context coding method is used.

Context coding has also been used to code bilevel images in standards such as JBIG and also in wavelet encoders as described in, K. Nguyen-Phi and H. Weinrichter, DWT image compression using Contextual bitplane coding of wavelet coefficients, Proc. ICASSP 97, pp. 2969-2971, 1997.

Without contexts, or with only one context, the probability of a zero would be estimated as the number of zeroes seen so far, divided by the total number of symbols coded. Using contexts, a number of surrounding or preceding symbols are used to choose one out of several contexts. The contexts are chosen so that the symbols coded in the same context are expected to have similar statistics. In this case every context holds the number of zeroes and the total number of symbols seen in this context.

The probability of zero is then estimated as the number of zeroes divided by the total number of symbols. After the symbol is coded the context is updated.

Several ways of choosing the context for the symbols can be used. Also different ways of updating the contexts can be used. In a preferred embodiment the contexts is restarted for every new bit plane. This is due to the fact that different bit planes have different statistics and that statistics inside a bit plane is stationary enough.

The bits used for the estimation of a symbol that is to be encoded are put together and considered to form an integer number. This number is used to index a context. The indexed context is holding all previous statistics seen when the bits used for the estimation had this exact configuration.

In the following, the information of whether a coefficient is significant or not, is considered to be a bit plane of its own, called the significance plane. This bit plane is '1' if the coefficient in question has been found to be significant in the current bit plane or any previous bitplane.

For the raw bits of all coefficients only one context can be used. This is only slightly better than sending the bits raw without entropy coding. This is also true for the AC coefficients sign bits and these were also encoded using only one context. It should be

9

noted that it is possible to send them as raw bits and not encode them with arithmetic coding. This might reduce the performance but will increase the execution speed of the algorithm.

The DC sign bit is coded in a context chosen by adding together the number of DC neighbours that are marked in the significance plane and have a positive sign as is illustrated in Fig. 6. The AC coefficients zero bits (and significant bit) can be coded taking into account 6 neighbouring coefficients in the block and the same coefficient in three neighbouring blocks as is illustrated in Fig. 5. The information in the significance plane for these coefficients, is used for the context.

For the DC coefficient zero bits the context is chosen using the DC coefficients in all the neighbouring blocks. Also in this case the only thing considered is the significance plane.

The block cut_off is coded in the context of the cut_off symbols in 4 neighbouring blocks as is illustrated by Fig. 7. The diagonal number is also taken into account. This is done by using the four bits of the related cut off symbols and the diagonal, which is a 4 bit number and compose them into an 8 bit integer that indexes the context.

The results can be improved, for example by using some suitable post processing algorithm.

The computational complexity and memory requirements of the algorithm described herein are mainly due to the DCT computation and the use of arithmetic coding.

Since the algorithm is block-based, parallel implementation is possible. In particular, the parallel implementation of the transformation stage is possible. Assume that P processors are available, to process an NxM image which is divided in 8x8 blocks, then each processor can do the DCT transformation in the blocks of the (N/P)xM part of the image. Furthermore, bitplanes can be processed independently and parallel. This is due to the fact that the contexts are restarted in each bitplane and that no grouping of coefficients is performed. All that needs to be known in a specific bitplane is which coefficients are significant previous of that bitplane. This information can be derived (also in parallel) from the DCT coefficients immediately after the transformation. Notice that the sign bit needs to be coded in a simple fashion.

Notice that the algorithm is very well suited for progressive image transmission. During progressive image transmission, it is desired to provide lossless compression at the last stage of the transmission. Without any restriction on the accuracy of DCT, near lossless reconstruction can be achieved. Lossless reconstruction can be achieved by a lossy plus lossless residual encoding method in which case the proposed algorithm is used for achieving the lossy part of the compression. Notice that this approach requires an integer inverse DCT to ensure portability of software and hardware.

In certain applications, particular regions of an image need to be coded with better quality compared to the other parts. The algorithm can be used for coding Regions of Interest (ROI) with different quality compared to the rest of the image. For example, if a ROI is to be coded at 1 bit per pixel (bpp) and the rest of the image at 0.5 bpp, then during a progressive image transmission, the image could be transmitted until the 0.5

10

bpp is achieved and then information to reconstruct the ROI at an additional 0.5 bpp could be transmitted (this is only a possible scenario). The ROI can also be coded lossless with the method described in previous paragraph. Notice that the ROI might have arbitrary size. In this case the methods used in MPEG 4 can be applied (block padding or Shape Adaptive DCT). Some modifications to the algorithm will however be required to make it work with arbitrary ROI's. Various schemes for progressive coding with ROIs are described below. Notice that for simplification purposes it is assumed that the ROI shape is a union of rectangles where the dimensions of the rectangles are the ones used for DCT coding (i.e. 8x8 pixels in most applications using JPEG).

Assuming that the bitrate for the background is x bits/pixel (bpp) and for the ROI is y bpp (y>x). Different schemes can be used to achieve progressive transmission of the image where the background is coded at x bpp and the ROI (or more ROI's) at y bpp (the bitrate for different ROI's can be different)

Below, three different schemes for obtaining such different bitrates are outlined.

In a first scheme the background (BG) and the region of interest (ROI) are coded separately. Such a scheme might result in some problems for progressive transmission, since the BG and the ROI are coded separately, there must be a way to pack the 2 different bitstreams in one so that to achieve progressive transmission of the whole image. Alternatively, the progressive transmission will result in BG or ROI send first and then the other (ROI or BG) send last. This means that the receiver cannot get an idea of what the whole image is at an early stage of the transmission.

Furthermore, correlation between neighbouring blocks in BG and ROI is not exploited, since they are coded separately. This will reduce the compression performance. The method is however good for parallel processing.

In a second scheme the ROI coefficients are shifted or multiplied by a certain number. This method will result in that the ROI coefficients are found significant at the early stages of the transmission and therefore to be coded first, as compared to the BG. The more the ROI coefficients are shifted, the earlier the ROI coefficients will be found significant. Therefore, it is possible to control the speed reconstruction of the ROI. The decoder needs to know the ROI shape and location as well as the shifting factor used for the ROI coefficients. This information is stored at the header information of the bitstream and the decoder can find it when receiving the bitstream. Notice that the number of ROIs can be arbitrary and the shifting (multiplying) factors of the ROI coefficients can be different for different ROIs. In this case, it is possible to control the ROI speed and importance.

Notice that if the coefficients are shifted so much that the smallest ROI coefficient is larger than the largest BG coefficient, then all ROI coefficients will be coded first. This will make the ROI to be reconstructed completely first (even up to lossless as will be described below). Also in this case the ROI shape is not needed to be transmitted. What needs to be transmitted is the shifting factor and a signal to the decoder telling that that the coefficients that have been received are ROI coefficients (alternatively, at the beginning of the header, the number of bytes that correspond to the ROI coefficients can be added so that the decoder knows when to stop decoding ROI coefficients). In this manner, there is no need to transmit the shape of the ROI, since

the decoder can find it. This might be important when the shape information is to occupy significant amount of bits (which is the case for arbitrary shaped regions). The saved bits can be used for better coding the ROI or the background. When the ROI bitrate is achieved, the decoder will know what will be received for the background.

Notice that the above scheme is not only applicable in DCT-based coders. Wavelet based coders can also use a similar scheme in order to avoid transmitting the shape information of the ROI's. The scheme can be used for example in Nister D., Christopoulos C.A., " Progressive lossy to lossless coding with a Region of Interest using the Two-Ten integer wavelet ", ISO/IEC JTC1/SC29/WG1 N744, Geneva, Switzerland, 23-27 March 1998.

It is also to be noted that this way of transmitting the shape of the ROI can be employed for any transmission scheme transmitting bitplanes in an order of decreasing significance. The only requirement is that the ROI coefficients are shifted with a factor large enough for them to be transmitted before any coefficient of the background. The method will work both for transformed images, e.g. DCT or wavelet transformed, as well as for ordinary bit plane coded images. In order for the receiver to know when the ROI coefficients information on when the last ROI coefficient has been transmitted must be transmitted to the receiver. This can be carried out in a number of different ways. For example, a signal can be transmitted, a bit plane consisting of only zero-valued coefficients, or a header in the beginning of the transmission indicating the number of bits used for the ROI coefficients.

Thus, only ROI is reconstructed at the early stages of the transmission. This makes it difficult for the receiver to know what the rest of the image looks like. This method is therefore good for speed reconstruction of the ROI. However, it avoids exploiting correlation between neighbouring blocks in BG and ROI at the early stages.

According to a third scheme all of the image is coded until the background bitrate (or desired quality) is achieved and then only the ROI is continued to be coded. The complexity of such a scheme remains similar to the one of the system described herein. Thus, there is no dynamic range increase, correlation between neighbouring blocks is exploited (at least until the BG rate is achieved). Furthermore it is possible that after the switch rate (from BG rate to improving the ROI) the remaining bits of the DCT coefficients in ROI will be raw bits. This means that there is little to gain by exploiting the correlation between these bits and then they can be coded even without an entropy coder.

Also, when using such a scheme a signal to the receiver needs to be sent when the BG rate is obtained, and that the ROI now is to be improved only. The decoder also needs to know the ROI shape. This method thus results in slower ROI reconstruction compared to the second scheme, but in all cases the receiver has an idea of the whole image.

The receiver can change the ROI location during the transmitting stage. When the receives gets an image in a progressive transmission manner, it can specify a particular ROI that he wants to see fast and/or with better quality than the rest of the image. The location and shape of the ROI is send to the transmitter. If the transmitter has the image in compressed form, it does a variable length decoding (arithmetic

12

decoding in our scheme) in order to find out the coefficients that correspond to the ROI. Then the transmitted uses one of the schemes described above. Notice that the transmitter needs to arithmetic encode the info again, but will not use the bitplanes that were already transmitted to the receiver. Also, the transmitter does not need to reconstruct completely the image (inverse DCT is not needed). If the transmitter has the original image also then he can use the scheme described above (do DCT first) to encode the non-transmitted bitplanes to satisfy the receiver request.

Notice that the schemes described above can be combined also, so that speed reconstruction of the ROI can be achieved at the early stages together with good quality background.

Finally it is to be noted that the algorithm as described herein is assumed to compress the components independently. With appropriate interleaving, an embedded bit-stream for the colour image can be produced.

The algorithm is based on DCT, which has been used in all still image and video coding standards. By appropriate quantization and the use of a context based arithmetic coding, an embedded DCT-based (EDCT) still image coding algorithm is achieved. This property is very useful in WWW applications and fast browsing of data bases.

Due to the fact that the algorithm is based on DCT, minimal modifications have to be made to the current JPEG architecture. Selective refinement, tiling, hierarchical coding and all modes of operations of the current JPEG are supported without introducing new types of artifacts.

Notice that other algorithms could be used instead of the DCT, as the Hadamard transform of the Fourier Transform. In addition, integer implementations of the DCT could be used. In this case the opportunity of lossless coding is achieved, and therefore progressive transmission from lossy to lossless can be achieved with the proposed scheme. As an example, if the DCT transform described by Ohta Mutsumi, "Lossless transform coding system for digital signals", US patent 5,703,799, Dec. 30, 1997, or if the algorithm of W.K. Cham and Y.T. Chan, "An Order-16 Integer Cosine Transform", Signal Processing, Vol. 39, No. 5, May 1991, pages 1205-1208 then an algorithm that can be used for both lossy and lossless coding is obtained using the methods described in our invention. Also, the possibility of obtaining the lossless ROI and lossy BG is achieved, in a fully progressive way by maintaining the embedded property of the algorithm.

The methods described above can be used for 3D coding or also video coding. In 3D coding, a fully embedded 3D coder can be achieved, where certain ROI's are coded with better quality than the rest of the image. This is particular useful in medical and remote sensing applications. In video coding, an embedded video coder can be designed. The EDCT can be used for coding both intra and inter macroblocks (for example in H.261, H.263 and MPEG video coding standards). Notice that the EDCT can also be used for the encoding of the motion vectors.

13

CLAIMS

1. A method of compressing a digitized image comprising the steps of:
- division of the image into blocks
- Discrete Cosine Transformation (DCT) of each block of the image,
- representation of each DCT block as a binary bit-plane,
characterized in that the DCT coefficients are scanned and transmitted in an order of decreasing bit-plane significance and, for each bit-plane, in a diagonal scan order starting from the upper left corner and ending in the lower right corner of each DCT block.

2. A method according to claim 1, **characterized in** that signals, cut_off signals, are transmitted when there are no more coefficients are to be transmitted for a particular block.

3. A method according to any of claims 1 or 2, **characterized in** that the output bits are coded by means of arithmetic coding.

4. A method according to claim 3, **characterized in** that the raw bits are not coded by arithmetic coding.

5. A method according to any of claims 1 - 4, **characterized in** that one coefficient is updated in all blocks before proceeding to the next coefficient.

6. A method according to any of claims 1 – 5, when the image to be compressed comprises region of interest (ROI) coefficients, **characterised in** that the ROI coefficients are shifted or multiplied with by a certain number.

7. A method according to claim 6, **characterised in** that ROI information is transmitted as header information in the beginning of the transmission.

8. A method according to any of claims 6 or 7, **characterised in** that coefficients of different region of interest are shifted/multiplied by different factors.

9. A method according to claim 6, **characterised in** that ROI coefficients are shifted so that they can be identified by a receiver without any additional information.

10. A method according to any of claims 1 – 5, when the image to be compressed comprises region of interest (ROI) coefficients, **characterised in** that all of the image is coded until a bitrate determined for background information is reached and that then only region of interest coefficients are continued to be coded.

11. A method according to claim 10, **characterised in** that a signal is transmitted to the receiver when the background bitrate is achieved.

12. A method according to any of claims 10 or 11, **characterised in** that a receiver receiving the compressed image can change the ROI during transmission of the image.

13. A method of transmitting an image comprising a region of interest (ROI), without transmitting the shape of the ROI, **characterised in** that the ROI coefficients are

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14

shifted before the transmission and that the bits of the image are transmitted in an order of decreasing bitplanes so that the ROI coefficients are transmitted first.

14. A method according to claim 13, **characterised in** that a signal is transmitted to a receiver informing the receiver when the transmission of ROI coefficients has ended.

15. A device for compressing a digitized image comprising means for:
- dividing the image into blocks
- Discrete Cosine Transforming (DCT) each block of the image,
- representing each DCT block as a binary bit-plane,
characterized by means for scanning and transmitting the DCT coefficients an order of decreasing bit-plane significance and, for each bit-plane, in a diagonal scan order starting from the upper left corner and ending in the lower right corner of each DCT block.

16. A device according to claim 15, **characterised by** means for transmitting signals, cut_off signals, when there are no more coefficients to be transmitted for a particular block.

17. A device according to any of claims 15 or 16, **characterised by** means for coding the output bits by means of arithmetic coding.

18. A device according to claim 17, **characterised by** means for coding the raw bits by another coding algorithm than arithmetic coding.

19. A device according to any of claims 15 - 18, **characterised by** means for updating one coefficient in all blocks before proceeding to the next coefficient.

20. A device according to any of claims 15 – 19, when the image to be compressed comprises region of interest (ROI) coefficients, **characterised in** that the ROI coefficients are shifted or multiplied with by a certain number.

21. A device according to claim 20, **characterised by** means for transmitting ROI information as header information in the beginning of the transmission.

22. A device according to any of claims 20 or 21, **characterised by** means for shifting coefficients of different region of interest by different factors.

23. A device according to claim 20, **characterised in** that ROI coefficients are shifted so that they can be identified by a receiver without any additional information.

24. A device according to any of claims 15 – 19, when the image to be compressed comprises region of interest (ROI) coefficients, **characterised by** means for coding the image until a bitrate determined for background information is reached and for thereafter only coding region of interest coefficients.

25. A device according to claim 24, **characterised by** means for transmitting a signal to the receiver when the background bitrate is achieved.

15

26. A device according to any of claims 24 or 25, **characterised by** means for receiving information from a receiver receiving the compressed image changing the ROI during transmission of the image.

27. A device for transmitting an image comprising a region of interest (ROI), without transmitting the shape of the ROI, **characterised by** means for shifting the ROI coefficients before the transmission and for transmitting the bits of the image are in an order of decreasing bitplanes so that the ROI coefficients are transmitted first.

28. A device according to claim 27, **characterised by** means for transmitting a signal to a receiver informing the receiver when the transmission of ROI coefficients has ended.
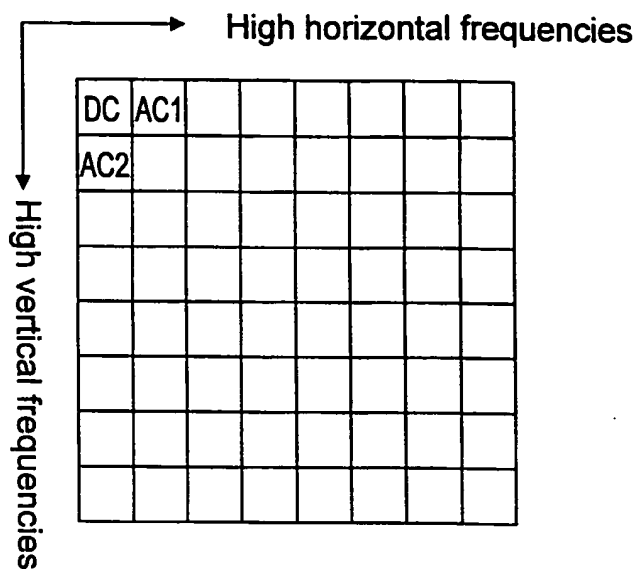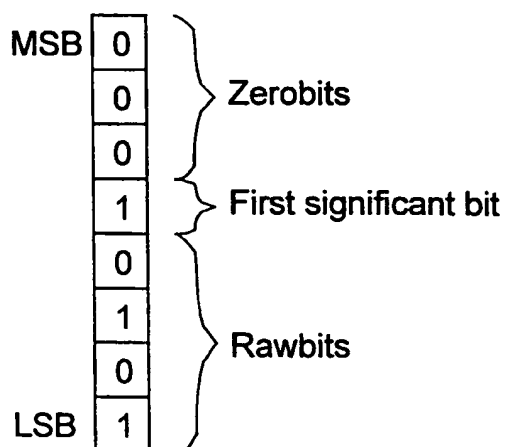
High horizontal frequencies

DC	AC1						
AC2							

High vertical frequencies

Fig. 1

MSB 0 ⎫
     0 ⎬ Zerobits
     0 ⎭
     1 } First significant bit
     0 ⎫
     1 ⎬ Rawbits
     0 ⎭
LSB 1 ⎫

Fig. 2

Diagonal scan of DCT-coefficients

Fig. 3

⊘ = Block cut off flag

Coefficient uncertainty
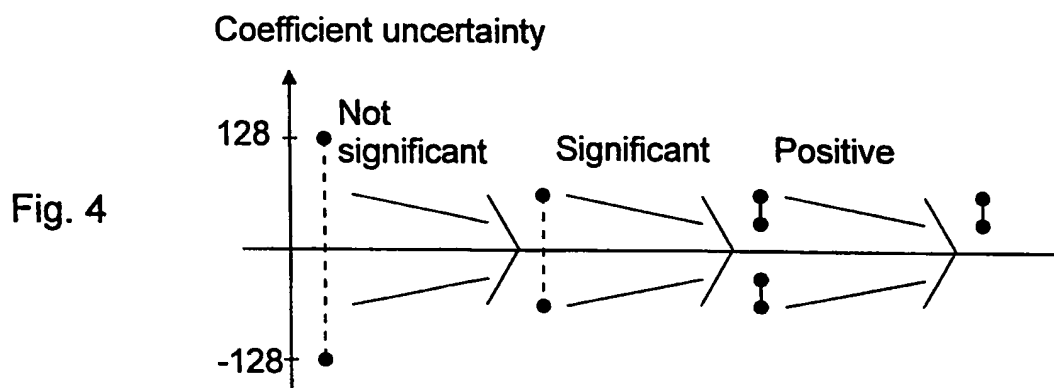

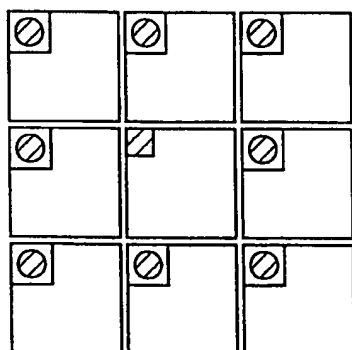Fig. 4
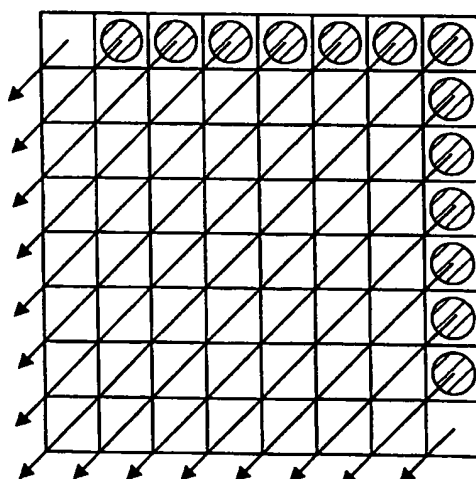
Fig. 5

☑ = Estimated bit

⊘ = Used for estimation
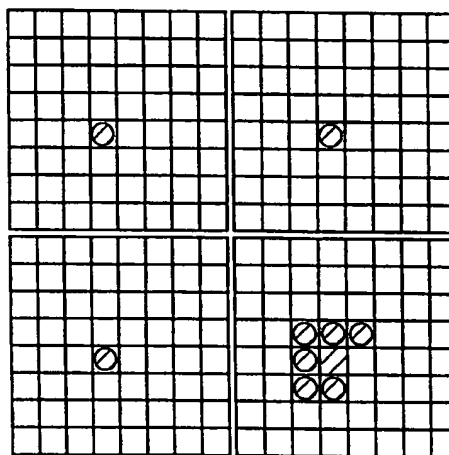
Fig. 6

☑ = Estimated bit

⊘ = Used for estimation

☑ = Estimated bit

⊘ = Used for estimation

Fig. 7

REFINEMENT PASS

First diagonal — 837

First coefficient in diagonal — 839

First block — 841

Is coefficient significant previously? — 843

No

Yes

Send raw bit — 845

Was this last block? — 847

Yes

No, next block

Last coefficient in diagonal? — 849

Yes

No, next coefficient

Was this last diagonal? — 851

Yes

No, next diagonal

Was this last bit plane? — 853

Yes

No, next bit plane

STOP — 855

Fig. 8

SIGNIFICANT IDENTIFICATION PASS

START — 801

Do forward DCT — 803

First bitplane — 805

reset contexts — 807

First diagonal — 809

First coefficient in diagonal — 811

First block — 813

Is block cut off already? — 815

Yes

No

Should cutoff be here? — 819

No

Yes

Send cutoff (yes/no) — 821

Is coefficient significant previously? — 823

Yes

No

Is coefficient significant now? — 825

No

Yes

Send not significant — 829

Send significant — 827

Send sign — 831

Was this last block? — 833

Yes

No, next block

Last coefficient in diagonal? — 817

Yes

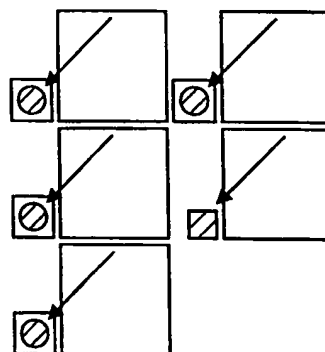No, next coefficient
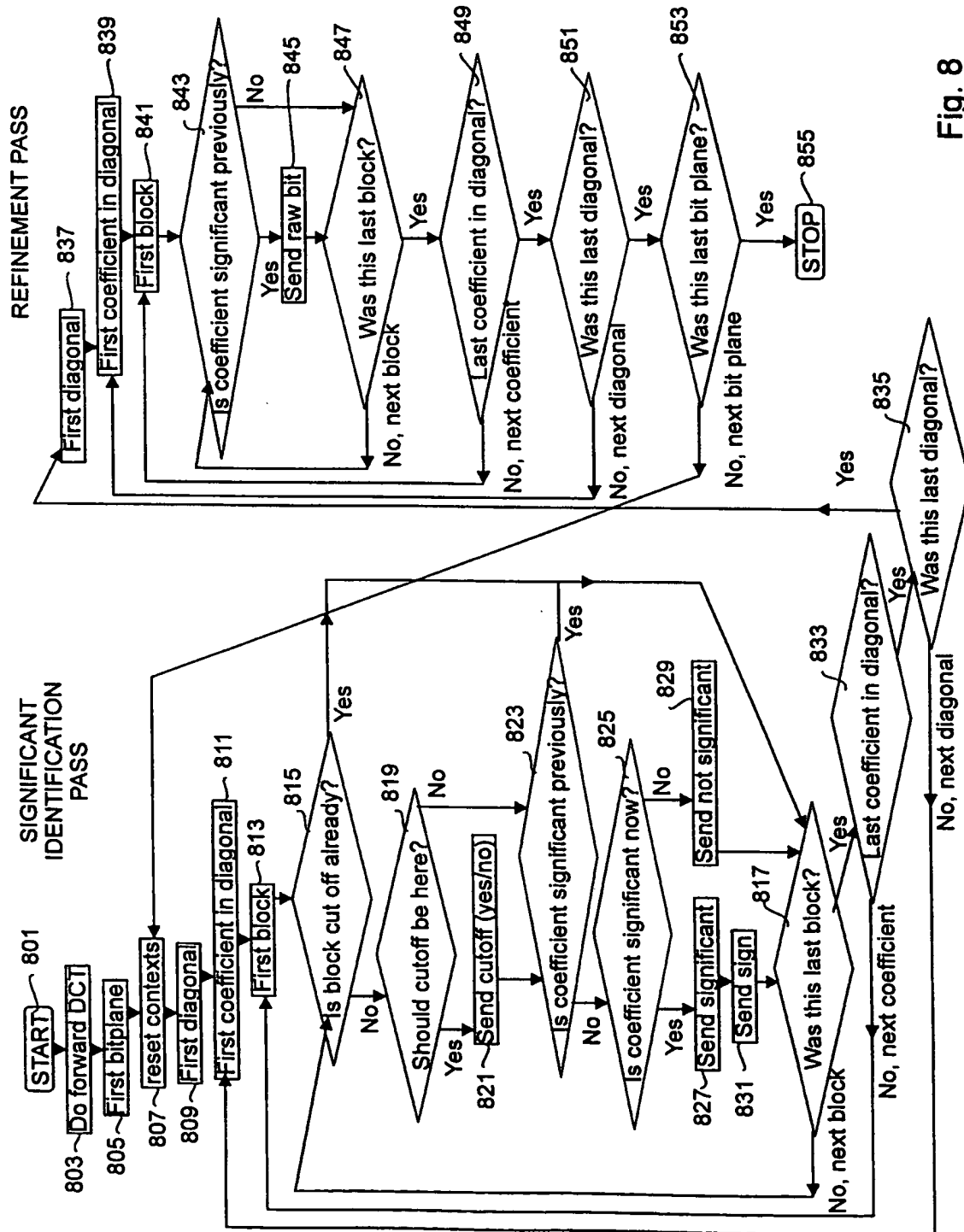
Was this last diagonal? — 835

Yes

No, next diagonal

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/01070

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04N 7/30, H04N 7/26, H04N 1/41

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4698689 A (KOU-HU TZOU), 6 October 1987 (06.10.87), column 1, line 60 - column 2, line 8; column 5, line 14 - column 6, line 11; column 9, line 28 - line 39, abstract --	1-5,15-19
X	US 5196933 A (JEAN-PIERRE HENOT), 23 March 1993 (23.03.93), column 2, line 33 - column 3, line 13; column 8, line 16 - line 42, abstract --	1-5,15-19
A	US 5363138 A (JUNJI HAYASHI ET AL), 8 November 1994 (08.11.94), abstract --	1-5,15-19

| X | Further documents are listed in the continuation of Box C. | X | See patent family annex. |

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Date of the actual completion of the international search	Date of mailing of the international search report
18 November 1998	1 8 -11- 1998

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PANAGIOTIDIS,N.G.; KOLLIAS, S.D. "Region-of-Interest Based Corporation of Magnetic Resonance Imaging Data". In: Proceedings /IWISP'96. Third International Workshop on Image and Signal Processing on the Theme of Advances in Computational Intelligence, Edited by MERTZIOS et.al. 4-7 Nov 1996, p. 31-5 see § 3 and 4	6-14,20-28
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A	US 5339108 A (CHARLES H. COLEMAN ET AL), 16 August 1994 (16.08.94), abstract	1-5,15-19
	--	
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